A REVISION OF THE FOSSIL FERNS FROM THE POTOMAC GROUP WHICH HAVE BEEN REFERRED TO THE GENERA CLADOPHLEBIS AND THYRSOPTERIS.

By Edward W. Berry,
Of the Johns Hopkins University, Baltimore.

The present paper is the fourth and last of a series of revisions of the more important genera of fossil plants from the Potomac group in Maryland and Virginia.[1] The following genera have been discussed in previous numbers of the Proceedings: *Nageiopsis, Acrostichopteris, Taeniopteris, Nilsonia, Sapindopsis, Sequoia, Athrotaxopsis, Sphenolepis, Abietites, Pinus, Cephalotaxopsis, Brachyphyllum,* and *Widdringtonites.*

With the appearance of the present communication all of the larger genera including those most in need of revision will have been treated. The remainder of the flora, numbering about one hundred species, will be fully described and illustrated in a Monograph of the Lower Cretaceous which will appear under the auspices of the Maryland Geological Survey.

The fern genus *Cladophlebis,* which is discussed in the first part of this paper, is an important cosmopolitan type in the Lower Cretaceous, a type which is an undiminished survival from the older Mesozoic. A large number of species have been described, both in this country and elsewhere. These ferns are abundant and important elements in the Potomac flora. The remains represent for the most part species of considerable size. The usual difficulties in dealing with fossil fragments of large and somewhat variable (in time and space) fronds have resulted in the previous description of many more species than the evidence warranted, a result equally confusing to both the botanist and the geologist.

The numerous species of *Thyrsopteris* recorded in the literature from the Maryland-Virginia area are treated in the second part of

[1] The previous papers are: (1) A revision of the fossil plants of the genus Nageiopsis of Fontaine, Proc. U. S. Nat. Mus., vol. 38, 1910, pp. 185-195. (2) A revision of the fossil plants of the genera Acrostichopteris, Taeniopteris, Nilsonia, and Sapindopsis from the Potomac group, Proc. U. S. Nat. Mus., vol. 38, 1910, pp. 625-644. (3) A revision of several genera of Gymnospermous plants from the Potomac group in Maryland and Virginia, Proc. U. S. Nat. Mus., vol. 41, 1911, pp. 289-318.

the paper in a markedly different manner from what has previously been customary and are considered as representing the polypodiaceous genus *Onychiopsis* of Yokoyama.

THE GENUS CLADOPHLEBIS.

The genus *Cladophlebis* is essentially a form-genus which is restricted at the present time to include only certain fern remains of Mesozoic age, although this type of frond is practically identical with those of some Paleozoic genera, as for example *Pecopteris*, and it can also be closely matched by a variety of Tertiary and living ferns.

Cladophlebis was proposed by Brongniart in 1849[1] for those species which formed the section *Pecopteris neuropteroides* in his "Histoire des végétaux fossiles" which he regarded as transitional between *Pecopteris* and *Neuropteris*. Certain of their characters were mentioned but no formal diagnosis was attempted. Saporta was perhaps the first to define the genus with precision.[2]

Schimper in 1874 gives a somewhat amplified diagnosis.[3] Later this author[4] abandons *Cladophlebis* in the belief that the fertile specimens described by Heer justify the reference of these forms to the modern genus *Asplenium*.

The most recent diagnosis is that by Seward, which may appropriately be quoted for the American Cretaceous forms:

> Fronds pinnately divided, pinnæ spreading, lobes or pinnules attached by the entire base or slightly auriculate, acuminate, or obtuse, occasionally dentate, especially at the apex, not rarely subfalcately curved upwards, midrib strong at base, and towards the summit dissolving into branches, secondary veins given off at a more or less acute angle, dichotomous a little above the base, and repeatedly dichotomous.[5]

Much difference of opinion has prevailed regarding the unity and the systematic position of the genus, Saporta[6] having long ago pointed out that Brongniart's species had nothing in common with those of the Mesozoic and that the Liassic and Oolitic forms, those which the former author was discussing, give evidence of common characters. At the present time there is still lacking evidence from such fructified remains as have been discovered of close relationship between all of the various species of *Cladophlebis*. Thus Heer discovered in the Siberian Jurassic, fragments of the *Cladophlebis whitbyensis* type with soral characters which he compared with those of the subgenus *Diplazium* of *Asplenium*[7] and Schenk has figured fertile pinnules of the same type in the case of the allied *Asplenites*

[1] Tableau, p. 25.
[2] Saporta, Pal. France, ser. 2, Végétaux, Plantes Jurass., vol. 1, 1873, pp. 298, 299.
[3] Schimper, Pal. Végét., vol. 3, 1874, p. 503.
[4] Schimper in Zittel's Handbuch der Palaeontologie, Abth. I, 1890, pp. 99, 100.
[5] Seward, Wealden Flora, pt. 1, 1894, p. 88.
[6] Saporta, Pal. France, ser. 2, Végétaux, Plantes Jurass., vol. 4, 1888, p. 357.
[7] Heer, Flora foss. Arct., vol. 4, 1877, p. 38, pl. 21, figs. 3, 4.

roesserti.[1] Certain specimens of the Jurassic species *Cladophlebis lobifolia* show that the sporangia in this species were apparently borne in semicircular pocket-like depressions on the edges of the fertile segments[2] while the fructifications of *Cladophlebis denticulata* are in the form of narrow oblong sori parallel with the secondary veins and are compared by Seward[3] with the modern forms *Asplenium lugubre* and *Phegopteris decussata*.

In his latest utterance on this subject Professor Seward says that "there are fairly good grounds for the assertion that some at least of the fronds described under this name are those of Osmundaceæ."[4]

Zeiller has recently described a species from the Wealden of Peru which he considers identical with, or very close to, *Cladophlebis browniana* in which the sporangia are biseriate, oval, and annulate as in the Schizaeaceæ. These are said to be very like those of the Jurassic genus *Klukia* of Raciborski.[5]

In the Potomac flora[6] we find that 14 so-called species of *Aspidium* Swartz (*Dryopteris* Adanson), mostly fertile fronds, were described by Fontaine in 1890. These showed mostly large elliptical or reniform sori in rows on each side of the midvein and located generally on the distal branch of a furcate vein and usually wanting in the apical part of the pinnule. These were compared by this author with modern species of *Aspidium*, *Cystopteris*, *Polystichum*, and *Didymochlaena*. The preservation is not of the best, the matrix being coarse, and Fontaine's figures are largely idealized. It has seemed remarkable that the fronds of *Dryopteris* in the Potomac beds were almost always fertile, while those of *Cladophlebis*, in intimate association with them, were invariably sterile.

By careful comparison it has been possible to correlate the fertile specimens described as *Dryopteris* with the sterile *Cladophlebis* fronds of the same species in five of the types which are represented in the Potomac flora by sterile and fertile fronds, and the presumption is strong, although unverified, that the remaining *Dryopteris* forms represent fertile fronds of *Cladophlebis*. While the foregoing facts are not in unison in regard to the systematic position of *Cladophlebis*, they all point to the inclusion of the following American species in the family Polypodiaceæ or in what represented this family in Lower Cretaceous times, and cast doubt upon Raciborski's suggestion that *Cladophlebis denticulata* and other species of the same genus were the sterile fronds of osmundaceous ferns. It is quite possible that ferns of more than one subfamily of the Polypodiaceæ, or indeed of other families, are

[1] Schenk, Flora Foss., Grenz. Keup. Lias, 1867, p. 51, pl. 7, figs. 7, 7*a*.
[2] Seward, Jurassic Flora, pt. 1, 1900, p. 23.
[3] Idem, p. 141.
[4] Seward, Fossil Plants, vol. 2, 1910, p. 345.
[5] Zeiller, Comptes Rendus, vol. 150, 1910, p. 1488.
[6] Fontaine, Monogr. U. S. Geol. Surv., vol. 15, 1890, pp. 93-104.

included among the various described species of *Cladophlebis*. It need but be remembered how many unrelated modern ferns have fronds of the *Cladophlebis* type, as for example certain species of *Alsophila, Asplenium, Cyathea, Dryopteris, Gleichenia, Onoclea, Osmunda, Pteris, Polypodium*, etc., to cast doubt upon the botanical affinity of *Cladophlebis* species unless these are attested by a considerable body of evidence. It is believed, however, that the Potomac species are all to be included in the subfamily Aspidieæ, or as it is more properly known, Dryopterideæ; and because of this, and also because their actual identity with the modern genus *Dryopteris* or in fact with any of the modern genera in this subfamily is extremely questionable, it has seemed wiser to use the more general name *Cladophlebis* instead of using *Dryopteris* where the sterile and fertile fronds have been correlated.

A large number of species of *Cladophlebis* have been described, two species, according to Arber, occurring in the Permo-Carboniferous of India. The genus appears in force in the Keuper and Rhaetic with more than a dozen recorded species. Over a score are recorded during the Jurassic, certain types such as *Cladophlebis denticulata* apparently becoming world wide in their distribution. For the Lower Cretaceous Saporta has founded a large number of species based upon Portuguese material and Fontaine has instituted a still larger number of American species. From the Potomac beds of Maryland and Virginia the latter author recorded 23 different species besides several varieties of *Cladophlebis*, altogether losing sight of variations and changes due to age or to position of the fossils with regard to the frond as a whole, as well as changes due to the direct action of the environment. These species were often based upon such insufficient material that it becomes almost impossible to deal with them with any degree of assurance. In considering all of the more representative material, and including with it all of the forms recorded from Maryland, we have a total of 8 species, and these 8 species include remains which were the basis for 23 of Fontaine's species and varieties of *Cladophlebis*, 6 of his species of *Dryopteris* and 9 of his species of *Pecopteris*.

CLADOPHLEBIS ALBERTSII (Dunker) Brongniart.

Neuropteris albertsii DUNKER, Monogr. Norddeutsch. Wealdenbildung, 1846, p. 8, pl. 7, figs. 6, 6*a*.

Alethopteris albertsii SCHIMPER, Pal. Végét, vol. 1, 1869, p. 570.

Pecopteris whitbiensis TRAUTSCHOLD, Nouv. Mém. Soc. Nat. Moscou, vol. 13, 1870, p. 27, pl. 19, fig. 2.

Pteris ? albertsii HEER, Flora foss. Arct., vol. 6, Abth. 2, 1882, p. 29, pl. 16, figs. 5, 6; pl. 28, figs. 1–3; pl. 46, figs. 22–24.

Pteris albertini VELENOVSKY, Abh. k. böhm. Ges. Wiss., vol. 2, 1888, p. 15, pl. 4, figs. 6–10 (not fig. 5).

Cladophlebis albertsii BRONGNIART, Tableau, 1849, p. 107.—SEWARD, Wealden Flora, pt. 1, 1894, p. 91, pl. 8.

Cladophlebis inclinata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 76, pl. 10, figs. 3, 4; pl. 20, fig. 8.

Cladophlebis denticulata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 71, pl. 4, fig. 2; pl. 7, fig. 7 (not Nathorst).

Cladophlebis, sp., FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 77, pl. 10, figs. 5, 8; pl. 20, fig. 7.

Cladophlebis pachyphylla FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 80, pl. 25, fig. 9.

Cladophlebis, sp., FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 77, pl. 15, fig. 6; pl. 19, fig. 3.

Aspidium angustipinnatum FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 98, pl. 16, figs. 1, 3, 8; pl. 17, fig. 1; pl. 19, fig. 10.

Dryopteris angustipinnata KNOWLTON, Bull. 152, U. S. Geol. Surv., 1898.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 540, 544, 548, pl. 114, fig. 6.

Aspidium oerstedi ? FONTAINE, Monogr. 15, U. S. Geol. Surv., 1890, p. 99, pl. 19, fig. 4 (not Heer).

Dryopteris oerstedi ? KNOWLTON, Bull. 152, U. S. Geol. Surv., 1898, p. 92.

Description.—A large amount of material has been referred to this species since Dunker's day, so that his diagnosis may be considerably amplified. In general these forms show the following characters:

Fronds large, bipinnate or tripinnate. Rachis stout. Pinnæ linear lanceolate, alternate to subopposite, becoming pinnatifid distally. Pinnules usually attached by their whole base, which is slightly expanded, contiguous but usually separated to the base, lanceolate, slightly falcate, acuminate. Margin usually entire, more rarely somewhat dentate in the apical portion. Venation of the usual *Cladophlebis* type. Fertile fronds have the rachis more slender than in the sterile fronds. The sori are borne on a distal branch of a furcate vein, as in other Potomac species of *Cladophlebis*, and form a row on either side of the midvein of the pinnules, which are otherwise indistinguishable from the sterile pinnules, though inclined to be straighter.

This species has been made to include a large amount of material from various horizons and localities which in the first instance was described as various species of *Neuropteris*, *Alethopteris*, *Pecopteris*, *Pteris*, etc. It is not at all certain that the result may not be a composite species made up of several distinct species with indistinguishable vegetative characters, and it would not be difficult to select still other forms from various parts of the world which could scarcely be separated from the foregoing.

Cladophlebis albertsii was not recognized as such in Professor Fontaine's Potomac studies, but it is obvious that the forms described as *Cladophlebis inclinata* and *Cladophlebis denticulata* (this was described as a new species and is decidedly different from Brongniart's species of the same name which Nathorst has referred to *Cladophlebis*) and as *Aspidium angustipinnatum* are identical with

each other and with those ferns in the European Wealden which are referred to *Cladophlebis albertsii*. The additional fragments of Potomac ferns which are referred to this species are not common and are equally unimportant botanically and stratigraphically. The two *Cladophlebis*, sp., Fontaine are clearly enough referable to this species. *Cladophlebis pachyphylla* is considered as an anomalous pinna, with thicker, more remote pinnules, which are contracted at the base. It was founded on a single fragment from Fredericksburg, Virginia, and if not an example of this species is simply a distal aberrant pinna of one of the other described species from that locality. The specimen which was the basis for the presence of *Aspidium oerstedi* Heer in this flora is the merest fragment without significance in any way.

The fertile pinnæ of *Cladophlebis albertsii* agree with those of *Cladophlebis parva* and other Potomac species in the general character, form and arrangement of the sori, the nature of the material precluding any more detailed information on this point. The sori appear to be confined to the basal part of the proximal pinnules. The present species is closely related to the contemporaneous form *Cladophlebis virginiensis* Fontaine.

It is common in the Wealden of England and Germany and probably in homotaxial beds in Austria and Russia. It has been recorded from the Cenomanian of Bohemia and from the Atane beds of Greenland, but both of these determinations may be considered as very doubtful. In this country it is definitely known only from the Potomac group. It has been recorded from the Patapsco formation at Vinegar Hill, Maryland, but the single specimen is referred by the writer to *Cladophlebis virginiensis* which is abundant at this locality.

Occurrence.—PATUXENT FORMATION: Potomac Run, Telegraph Station (Lorton), Dutch Gap, Trents Reach, Fredericksburg, Virginia. ARUNDEL FORMATION: Arlington, Hanover, Bay View, Maryland.

Collections.—United States National Museum, Goucher College.

CLADOPHLEBIS BROWNIANA (Dunker) Seward.

Pecopteris browniana DUNKER, Monogr. Norddeutsch. Wealdenbildung, 1846, p. 5, pl. 8, fig. 7.—FONTAINE, Monogr. U. S. Geol. Survey, vol. 15, 1890, p. 88, pl. 22, figs. 10, 11; pl. 23, figs. 2–7; pl. 26, figs. 3, 13; Proc. U. S. Nat. Mus., vol. 15, 1892, p. 492.—DAWSON, Trans. Roy. Soc. Can., vol. 10, sec. 4, 1893, p. 84, fig. 3.—YOKOYAMA, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 218, pl. 24, figs. 2, 3; pl. 27, figs. 1–5.

Alethopteris reichiana ETTINGSHAUSEN, Abh. k. k. geol. Reichs., vol. 1, Abth. 3, 1852, p. 17.

Alethopteris browniana SCHIMPER, Pal. Végét., vol. 3, 1874, p. 502.

Cladophlebis browniana SEWARD, Wealden Flora. pt. 1, 1894, p. 99, pl. 7, fig. 4.—Ann. S. Afr. Mus., vol. 4, 1903, p. 10, pl. 2, figs. 1–4, 6.—KNOWLTON, Smiths. Misc. Coll., vol. 4, pt. 1, 1907, p. 108, pl. 11, fig. 1.—KNOWLTON, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 386.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 272, 510, 517, 538, 544, 547, 557, 572.

Pecopteris cf. *Browniana* NATHORST, Denkschr. k. Akad. Wiss. Wien, vol. 57, 1890, p. 53, pl. 5, fig. 5.

Cladophlebis inaequiloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 80, pl. 25, fig. 8.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 510.

Cladophlebis petiolata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 80, pl. 22, fig. 8.

Cladophlebis oblongifolia FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 74 (part), pl. 7, fig. 5 (not figs. 3, 4 which are referred to *Cladophlebis virginiensis* Fontaine).

Cladophlebis crenata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 75, pl. 9, figs. 7–9; pl. 10, figs. 1, 2; pl. 13, figs. 1–3; pl. 19, fig. 7; pl. 20, fig. 6.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 547.

Cladophlebis alata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 77, pl. 19, fig. 5.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 229, 480, 510, 544, 557, pl. 65, figs. 17–21.

Cladophlebis inclinata FONTAINE, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.

Cladophlebis, sp., FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 78, pl. 19, fig. 2.

Pecopteris strictinervis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 84, pl. 13, figs. 6–8; pl. 19, fig. 9; pl. 20, fig. 3; pl. 22, fig. 13; pl. 170, figs. 5, 6.

Pecopteris ovatodentata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 85, pl. 15, fig. 8; pl. 22, fig. 12; pl. 23, fig. 1.

Pecopteris microdonta FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 85, pl. 19, fig. 8; pl. 20, figs. 5, 11.

Pecopteris virginiensis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 82, pl. 8, figs. 1–7; pl. 9, figs. 1–6; pl. 24, fig. 2; pl. 169, fig. 3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 480, 538, 552, pl. 116, figs. 3, 4.

Pecopteris constricta FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 86, pl. 20, figs. 1, 2, 4.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 519.

Pecopteris socialis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 87, pl. 21, fig. 7 (not Heer, 1882).

Pecopteris angustipennis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 87, pl. 21, fig. 10.

Pecopteris cf. *virginiensis* YOKOYAMA, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 220, pl. 24, fig. 1.

Description.—The American material which the writer refers to this species is much more abundant than that from abroad, and the following diagnosis may be attempted:

Frond bipinnate or tripinnate. Pinnæ elongate, linear in outline.[1] Pinnules approximate, variable in outline, usually obtuse and becoming united distad to form a pinnatifid pinna, which is then constricted and slightly decurrent at the base. Venation of the *Cladophlebis* type not well seen in the smaller pinnules because of their coriaceous texture.

This is another cosmopolitan species of *Cladophlebis* which may be composite in nature and which, as commonly preserved in frag-

[1] The single form which Fontaine identified with this species has pinnæ which shorten rapidly, giving the frond a deltoid form, and may be properly referable to the allied species *Cladophlebis ungeri*.

mentary specimens, is distinguishable with difficulty from its congeners. It is especially close to *Cladophlebis albertsii* and *Cladophlebis ungeri*. It is recorded from the uppermost Jurassic and lowermost Cretaceous in Portugal, from the Neocomian of Japan, and from the Wealden of England, Germany, and Austria. In America it has been reported from the Shasta through the Horsetown and in the base of the Chico formation on the Pacific coast, and from the Kootenai formation of Montana and British Columbia.

It is well scattered and abundant in the Potomac group, occurring in all three of the formations, but represented for the most part by incomplete specimens showing slight variations, which were made the basis for many species of Professor Fontaine. Material from the Patapsco formation of Maryland shows indistinct oval sori in a single row on either side of the midvein. These are of the type found associated with a number of other American species of *Cladophlebis*.

Professor Zeiller [1] has recently reported fertile fronds of *Pecopteris browniana*, or of a very similar species, from the Wealden of Peru. These are not figured, but are described as having biseriate, oval, annulate sporangia as in the modern family Schizaeaceæ and very like those of the Jurassic genus *Klukia* of Raciborski, thus apparently somewhat different from those of the American representatives of the present species. Fragments from the Neocomian of Japan, showing oval sori, are referred to this species by Yokoyama.[2]

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Alum Rock, Telegraph Station (Lorton), Potomac Run, Virginia; New Reservoir, Ivy City, District of Columbia; Broad Creek (?), Maryland. ARUNDEL FORMATION: Arlington, Hanover, Howard Brown Estate, Maryland. PATAPSCO FORMATION: Brooke and vicinity, Chinkapin Hollow, Virginia; Federal Hill (Baltimore), Vinegar Hill, Maryland.

Collections.—United States National Museum, Johns Hopkins University, Goucher College.

CLADOPHLEBIS CONSTRICTA Fontaine, emended.

Cladophlebis constricta FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 68, pl. 2, fig. 11; pl. 3, fig. 2; pl. 6, figs. 5,6, 8–14; pl. 21, figs. 9, 13; pl. 169, fig. 2.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 280, 297, 504, 528, 547, pl. 77, fig. 26.—PENHALLOW, Summ. Geol. Surv. Can., 1904 (1905), p. 9.—KNOWLTON, Smiths. Misc. Coll., vol. 4, pt. 1, 1907, p. 109.

Cladophlebis latifolia FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 69, pl. 3, fig. 1; pl. 6, fig. 4.

Cladophlebis virginiensis FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 512, pl. 111, fig. 7.

[1] Zeiller, Comptes Rendus, vol. 150, 1910, p. 1488.

[2] Yokoyama, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 220.

Description.—Frond large, bipinnate or tripinnate. Principal rachis rather slender. Pinnæ remote, shortening rapidly distad. Proximad they are pinnatifid, changing first into pinnules with undulate margins and then into those with entire margins in passing toward the apex of the frond. Pinnules elliptical in outline, constricted at the base, which is rounded or subauriculate. Venation of the usual Cladophlebis type.

This species has been identified at a number of localities in Maryland and Virginia, but it is not common at any of these. Outside this area it has been reported from the Kootenai of Montana, and very similar forms occur in the Kome beds of Greenland, as, for example, those which Heer described as *Pecopteris arctica*,[1] *Pecopteris andersoniana*,[2] and *Pecopteris hyperborea*.[3] Abroad the species described by Schenk [4] from the German Wealden as *Alethopteris cycadina* is very close to the American species, as Fontaine has already pointed out.

Cladophlebis constricta exhibits considerable variation in the degree of remoteness and outline of the pinnules, and may possibly include more than one species, the fact that certain of these aberrant forms come from the low horizon at Fredericksburg while all of the other occurrences are from Patapsco outcrops lends some credence to this suggestion. The species has been reported by Penhallow from the Kootenai in Canada, but this determination can not be accepted with certainty.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Virginia. PATAPSCO FORMATION: Hell Hole (?), Brooke, Deep Bottom, Virginia; Federal Hill (Baltimore), Vinegar Hill, Fort Foote (?), Maryland.

Collections.—United States National Museum.

CLADOPHLEBIS DISTANS Fontaine, emended.

Cladophlebis distans FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 77, pl. 13, figs. 4, 5.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 280, 572.

Dryopteris fredericksburgensis KNOWLTON, Bull. 152, U. S. Geol. Surv., 1898, p. 92.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 280, 512, 538, 548, pl. 112, fig. 2.

Aspidium fredericksburgense FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 94, pl. 11, figs. 1–6; pl. 12, figs. 1–6; pl. 16, fig. 9; pl. 19, figs. 6, 7.—PENHALLOW, Trans. Roy. Soc. Can., sec. 3, vol. 1; sec. iv, 1908, p. 307.

Description.—Frond large and coarse, bipinnate or tripinnate. Rachis very stout and rigid. Pinnæ of the ultimate order mostly alternate, rarely opposite or subopposite, with rigid and proportionally rather slender rachises, very long, linear. Pinnules alternate,

[1] Heer, Flora foss. Arct., vol. 1, 1868, p. 80, pl. 1, fig. 13; pl. 43, fig. 5.
[2] Idem., vol. 3, Abth. 2, 1874, p. 41, pl. 3, fig. 7*b*.
[3] Idem., vol. 1, 1868, p. 81, pl. 44, fig. 4.
[4] Palaeont., vol. 19, 1871, p. 218, pl. 31, fig. 2.

oblong or ovate, obtuse, slightly falcate, and usually with a somewhat rounded and slightly constricted base, separate, more or less remote, in some specimens those of the lower pinnæ with crenate margins, those of the upper ones entire, passing in the middle part of the frond through pinnules with undulate margins. Leaf-substance thick and leathery. Midvein of the usual *Cladophlebis* type, that is, strong at base and dissolving into branches at the summit; lateral nerves of the crenate and undulate pinnules in groups in each tooth, composed of a midvein which sends off alternate simple branches, or else of forked veins with one of the branches forking again; those of the pinnules with entire margins usually once forked, all quite distinct; fertile specimens rare. Sori very large, elliptical or reniform in shape, and distributed in two rows, one on each side of the midvein, attached to the summit of the upper branch of a furcate nerve.

This species is quite generally distributed throughout the Potomac formations, although there is but one recorded occurrence from the Arundel formation. It is abundant in the Patuxent formation at Fredericksburg and outside the Maryland-Virginia area it has been recorded from the Kootenai formation of Montana and British Columbia and the Shasta of the Pacific coast province.

The sterile and fertile pinnæ are closely similar in outline and venation, the former being much more abundantly represented than the latter. They are both very similar to those of *Cladophlebis parva* Fontaine and may be compared with a number of European and Kome species of *Cladophlebis*, *Alethopteris*, *Pecopteris*, etc.

Occurrence.—Patuxent formation: Fredericksburg, Dutch Gap, Telegraph Station (Lorton), Virginia; Broad Creek, Maryland. Arundel formation: Arlington, Maryland. Patapsco formation: Chinkapin Hollow, Virginia.

Collections.—United States National Museum.

CLADOPHLEBIS PARVA Fontaine, emended.

Cladophlebis parva Fontaine, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 73, pl. 4, fig. 7; pl. 6, figs. 1–3.—Fontaine, in Ward, 19th Ann. Rep. U. S. Geol. Surv., pt. 2, 1899, p. 657, pl. 160, fig. 18; Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 225, 280, 510, 538, pl. 65, figs. 5–8.—Knowlton, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 386.

Cladophlebis inclinata Fontaine, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.—Fontaine, in Stanton, Bull. 133, U. S. Geol. Surv., 1896, p. 15.

Cladophlebis, sp., Fontaine, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 81, pl. 26, fig. 15.

Aspidium heterophyllum Fontaine, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 96, pl. 14, figs. 1–5; pl. 15, figs. 1–5.—Fontaine, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.—Fontaine, in Stanton, Bull. 133, U. S. Geol. Surv., 1896, p. 15.

Dryopteris heterophylla Knowlton, Bull. 152, U. S. Geol. Surv., 1898, p. 92.—Fontaine, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 483, 550, pl. 115, figs. 7, 8.

Description.—Fronds large, bipinnate or tripinnate. Rachis very stout. Pinnæ linear-lanceolate, becoming somewhat falcate in outline distad, and passing from alternate to subopposite. Pinnules relatively wide, falcate, acuminate in the sterile forms but obtuse in the fertile, variable in size according to their position. The distal pinnules which represent the reduced pinnæ lower down on the frond are larger and relatively more slender than the pinnules of the lateral pinnæ, which are almost as wide as they are long, and falcate. Between the two orders there is every gradation on each frond through pinnatifid pinnæ to simple pinnule-like forms. Margins entire or slightly crenate, especially in the fertile pinnules, which are wider than the sterile. Lateral veins usually but once forked, sometimes simple. Texture coriaceous. Sori large, reniform in outline, in three or four pairs on either side of the midvein at the end of a distal branch of a furcate vein. The structure or arrangement of the sporangia can not be made out but the spores are preserved in abundance. They are small, ranging from 0.083 mm to 0.05 mm in diameter, with very thick walls, the outer surface covered with fine granulations not visible with magnifications of 200 diameters or less. The tetrad scars are very distinct. In form as well as size these spores are variable. The smaller, possibly immature, spores are trigonal in outline, while the larger are more nearly spherical.

This is a large and handsome species and is represented in the collections by material of both the sterile and fertile fronds. It ranges from the bottom to the top of the Potomac deposits, and outside the Maryland-Virginia area is recorded from the Shasta beds of the Pacific coast, the Kootenai of Montana, and the Lakota formation of the Black Hills. There are a number of European Wealden species which are similar to *Cladophlebis parva*, but it is believed to be quite distinct from its contemporaries, although small fragments of almost any of the species of *Cladophlebis* are likely to be confused.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Cockpit Point, Potomac Run, Virginia. ARUNDEL FORMATION: Arlington (?), Maryland. PATAPSCO FORMATION: Vinegar Hill, Maryland.

Collections.—United States National Museum, Goucher College.

CLADOPHLEBIS ROTUNDATA Fontaine, emended.

Cladophlebis rotundata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 78, pl. 20, figs. 9, 10.—(?) PENHALLOW, Summ. Geol. Surv. Can. 1904 (1905), p. 9.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 491, 510.

Cladophlebis brevipennis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 81, pl. 36, fig. 1.

Description—In 1890 Fontaine describes this species as follows:

Frond bipinnate or tripinnate, arborescent(?); principal rachis stout, rounded, and prominent; pinnæ short, with a strong rigid rachis; ultimate pinnæ, from the lower.

part of the frond, with alternate, short, broadly ovate, very obtuse, round-lobed pinnules, those of the upper part of the frond having the lowest pinnules distinct and more or less round-lobed, and toward the summit with pinnules passing through such forms as rotundate, subrhombic, and decurrent to entire and rounded, the latter having the tips round-lobed and very obtuse; nerves varying according to the position and shape of the pinnules, those of the round-lobed pinnules and of the pinnæ reduced to pinnules flabellately diverging in each lobe, the branches being either forked or simple. The nerves of the subrhombic pinnules have a midnerve, which sends off alternately on each side forked or simple branches. All the nerves are very strongly marked and stout. The leaf-substance is thick and leathery.

The foregoing description was written for *Cladophlebis rotundata*, but it requires no alteration to include the rare fragments which were named *Cladophlebis brevipennis*, as the material on which the two were founded is identical; in fact, the description of the latter was practically a paraphrase of the former.

This species, while founded upon rather scant remains, is well characterized by the strong venation and the breadth of the short ovate pinnules. It may possibly represent *Cladophlebis constricta* Fontaine, as it closely resembles the form of the latter species which Professor Fontaine named *Cladophlebis latifolia*. It has been recorded by Penhallow from Yukon Territory in Canada, but the identification is very doubtful.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Virginia. PATAPSCO FORMATION: Mount Vernon, Chinkapin Hollow, Virginia.

Collections.—United States National Museum.

CLADOPHLEBIS UNGERI (Dunker) Ward.

Pecopteris ungeri DUNKER, Monogr. Norddeutsch. Wealdenbildung, 1846, p. 6, pl. 9, fig. 10.

Pecopteris polymorpha DUNKER, Monogr. Norddeutsch. Wealdenbildung, 1846, p. 6, pl. 7, fig. 5 (not Brongniart).

Pecopteris dunkeri SCHIMPER, Pal. Veget., vol. 1, 1869, p. 539.

Pecopteris exiliformis GEYLER, Palaeont., vol. 24, 1877, p. 226, pl. 30, fig. 1.

Aspidium dunkeri FONTAINE, Monogr. U. S. Geol Surv., vol. 15, 1890, p. 101, pl. 22, figs. 9, 9*a*, 9*b*; pl. 25, figs. 11, 12; pl. 26, figs. 2, 8, 9, 18; pl. 54, figs. 3, 9.—FONTAINE, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.—FONTAINE, in Stanton, Bull. 133, U. S. Geol. Surv., 1896, p. 15.

Cladophlebis dunkeri SEWARD, Wealden Flora, pt. 1, 1894, p. 100, pl. 7, fig. 3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 510, 538.

Pecopteris exilis YOKOYAMA, Journ. Coll. Sci. Japan, vol. 3, 1890, p. 35, pl. 1, figs. 8–10.

Aspidium parvifolium FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 100, pl. 21, fig. 6; pl. 24, fig. 8; pl. 25, fig. 10; pl. 26, figs. 1, 14, 16, 17.

Dryopteris parvifolia KNOWLTON, Bull. 92, U. S. Geol. Surv., 1898, p. 92.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 486 (not p. 541, pl. 114, fig. 7).

Pecopteris geyleriana NATHORST, Denkschr. k. Akad. Wiss. Wien, vol. 57, 1890, p. 48, pl. 4, figs. 2–6.—YOKOYAMA, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 219, pl. 21, fig. 12; pl. 23, figs. 1, 1*a*; pl. 38, fig. 5.

Pecopteris, sp., NATHORST, Denkschr. k. Akad. Wiss. Wien, vol. 57, 1890, p. 48, pl. 4, figs. 2–6.

Cladophlebis ungeri WARD in Fontaine, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 228, 510, 538, pl. 65, figs, 15, 16.—KNOWLTON, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 386.

Pecopteris brevipennis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 86, pl. 21, figs. 1–3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 510.

Pecopteris pachyphylla FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 88, pl. 26, figs. 4, 5.

Description.—A satisfactory diagnosis is the one written by Professor Fontaine for his *Aspidium Dunkeri* which will answer not only for that material but for all of the other supposed species founded by Fontaine upon various fragments of *Cladophlebis ungeri*. It is as follows:

Frond bipinnate or tripinnate, arborescent; principal rachis stout and rigid; ultimate pinnæ alternate, short, linear-lanceolate; pinnules alternate or subopposite, short, closely placed, narrowed at the base, cut more or less deeply into lobes or teeth which are ovate or oblong, obtuse or subacute, very small, those of the fertile portions of the frond standing nearly perpendicular to the rachis and having in each lobe or pinnule a simple lateral nerve which bears a sorus on its summit, those of the sterile and more common portions more obliquely placed, mostly subacute, with nerves in each lobe that fork simply in the upper ones, and in the lower ones are composed of a midnerve with alternate simple branches; leaf-substance thick; sori very minute, club-shaped or elliptical, visible distinctly only with the help of a lens, and present only in the pinnules of the lower part of the pinnæ, and mostly found on the lobes toward the base of these.

This species was described by Dunker in 1846 from the Wealden of Northern Germany as *Pecopteris ungeri* and *Pecopteris polymorpha*. Schimper in 1869 renamed the latter *Pecopteris dunkeri* for the reason that the specific name *polymorpha* had been used by Brongniart in 1828. Schenk two years later, with Dunker's original specimens before him, announced that Dunker's *ungeri* and *polymorpha* were synonymous. He did not, however, restore Dunker's name nor has Seward done so in his discussion (1894) of this species in the "Wealden Flora." In accordance with the prevailing system of nomenclature Dunker's original name must be used for this species, and this proposal was made by Ward in 1906. Seward in 1894 referred the species to the genus *Cladophlebis* and while the American material available in the present treatment of this species is not as complete as might be desired it furnishes some evidence regarding the fertile fronds of still another species of *Cladophlebis*. The character of the fertile material is rather vague and while it is clearly congeneric with a number of other of Fontaine's species of *Aspidium*, it is hardly sufficient evidence of their relationship with that modern genus.

The present species is close to *Cladophlebis browniana* and is apparently a cosmopolitan Lower Cretaceous type since indistinguishable material occurs not only in the English and Continental Wealden

deposits (Belgium, Germany, Austria), but in the Neocomian of Portugal and Japan, and in the Uitenhage series of South Africa. Material obtained from Japan shows obscure fruiting fragments in which the pinnæ are narrowed, and there is apparently a single sorus to each pinnule.[1] The species is also reported from the Albian of Portugal by Saporta. In America it is not rare in the Potomac beds and rather doubtful remains are referred to this species from the Shasta beds of California. It is probably represented in the Kootenai formation of Montana by *Dryopteris montanense* (Fontaine) Knowlton.[2] Professor Seward in a recent paper[3] expresses his belief that this species is identical with *Cladophlebis browniana*, such differences as are observable being merely individual and not specific. This may be the case as the two are certainly closely allied. There is, however, serious danger in uniting under a single specific name fern fronds from all quarters of the globe which resemble each other, unless the evidence of their identity is very strong.

Occurrence.—PATUXENT FORMATION: Woodbridge, Fredericksburg, Dutch Gap, Telegraph Station (Lorton), Virginia. PATAPSCO FORMATION: Chinkapin Hollow, Virginia.

Collections.—United States National Museum.

CLADOPHLEBIS VIRGINIENSIS Fontaine, emended.

Cladophlebis virginiensis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 70, pl. 3, figs. 3–8; pl. 4, figs. 1, 3–6 (not Fontaine, 1906).

Cladophlebis falcata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 72, pl. 4, fig. 8; pl. 5, figs. 1–6; pl. 6, fig. 7; pl. 7, figs. 1, 2.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 227, 280, 511, 548, pl. 65, figs. 12–14; pl. 111, fig. 6.—KNOWLTON, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 386.

Cladophlebis acuta FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 74, pl. 5, fig. 7; pl. 7, fig. 6; pl. 10, figs. 6, 7; pl. 11, figs. 7, 8; pl. 166, fig. 5.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 538, pl. 114, figs. 3, 4.

Thinnfeldia variabilis FONTAINE, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.—FONTAINE, in Stanton, Bull. 133, U. S. Geol. Surv., 1896, p. 15.

Cladophlebis acuta angustifolia FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 539, pl. 114, fig. 5.

Asplenium distans DAWSON, Trans. Roy. Soc. Can., vol. 3, sec. 4, 1886, p. 5, pl. 3, fig. 7 (not Heer).

Thinnfeldia montanensis FONTAINE, in Weed and Pirsson, 18th Ann. Rept. U. S. Geol. Surv., 1896–97 (1898), pt. 3, p. 481.

Cladophlebis falcata montanensis FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 291, pl. 71, figs. 14–20.

Cladophlebis oblongifolia FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 74 (part), pl. 7, figs. 3, 4 (not fig. 5, which is referred to *C. browniana*).

[1] Nathorst, Denkschr. k. Akad. Wiss. Wien, vol. 57, 1890, pl. 4, figs. 3–5; of these fig. 3 is referred to *Weichselia mantelli* by Seward, 1894.

[2] Fontaine, Proc. U. S. Nat. Mus., vol. 15, 1892, p. 490, pl. 82, figs. 1–3; pl. 83, figs. 2–3*a*.

[3] Seward, Ann. S. Afr. Mus., vol. 4, 1903, p. 10.

Description.—Frond large, bi- or tripinnate. Rachis stout and rigid. Ultimate pinnæ long, rather remote, alternate to subopposite. Pinnules ovate to lanceolate and subfalcate in outline, sometimes obtusely pointed mostly separate to the base, attached by their whole base which is more or less widened. Venation of the type usual in this genus. Margins usually entire, sometimes crenulate to subdentate becoming entire distad. Texture coriaceous. The degree of separateness of the pinnules as well as their relative length and breadth and their more or less falcate form are characters dependent upon the age of the frond or the position of the pinnules on the frond, long narrow almost straight proximal pinnules passing gradually into more or less short, broad and falcate distal pinnules.

This species is not very different from the widespread type of *Cladophlebis* commonly referred to the species *albertsii* of Brongniart. It exhibits considerable variation from specimen to specimen, but these variations show so many gradations and are so readily explained when the position of the various fossil fragments upon the frond is taken into consideration that any segregation of them is entirely unwarranted. In general the pinnules are larger and relatively much wider than in *Cladophlebis albertsii*.

The present species is very common at certain localities both in the Patuxent and Arundel formations, and although it apparently survives during the deposition of the Patapsco formation it is less common. Outside of the Maryland-Virginia area remains of this species have been reported from the Shasta beds of California and from the Kootenai of Montana and British Columbia. Seward [1] refers the bulk of Fontaine's figures of *Cladophlebis virginiensis* Fontaine to *Todites williamsoni* (Brongniart), a widespread older Jurassic species, but this reference has no justification. *Cladophlebis nathorsti* Yokoyama [2] from the Neocomian of Japan is very close to the present Potomac species.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Potomac Run, Virginia. ARUNDEL FORMATION: Arlington, Maryland. PATAPSCO FORMATION: Vinegar Hill, Maryland; Chinkapin Hollow, Virginia.

Collections.—United States National Museum, Goucher College.

THE GENUS ONYCHIOPSIS.

Yokoyama characterized the genus Onychiopsis as follows: "Fertile segments different from the sterile. Sori terminal, linear, on each side of the midrib, parallel with the margin, involucrate; the involucrum of each side confluent over the midrib." [3] It was based on a

[1] Seward, Fossil Plants, vol. 2, 1910, p. 340.
[2] Yokoyama, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 220, pl. 28, figs. 3, 4, 10, 11.
[3] Idem., vol. 3, 1890, p. 26.

Japanese Upper Jurassic or Neocomian species originally described by Geyler as *Thyrsopteris elongata* and founded upon sterile pinnules. The discovery of fertile pinnules by Yokoyama led to the erection of the present genus which is very close to the modern genus *Onychium* Kaulfuss, which is made a subgenus of *Cryptogramme* R. Brown by Diels in Engler and Prantl's Natürlichen Pflanzenfamilien (1899), although there seems to be but slight warrant for Diel's treatment.

Seward in working over the abundant Wealden material in the British Museum found that the widespread species which usually went by the name of *Sphenopteris mantelli* Brongniart was congeneric with Yokoyama's species mentioned above, and he therefore redescribed Brongniart's species as *Onychiopsis mantelli*, redefining the genus in the following terms:[1]

Frond tripinnate, main rachis slender, may be winged, pinnæ alternate, approximate, lanceolate. Pinnules narrow, lanceolate, acute, alternate, the larger ones serrate, and gradually passing into pinnules with narrow ultimate segments. Fertile pinnæ with alternate elliptical pinnules which differ in shape from the sterile pinnules and have the sporangia on the lower surface, giving them the appearance of raised elliptical bodies.

The most abundant and characteristic ferns of the Potomac group were referred by Professor Fontaine to *Thyrsopteris* Kuntze, an existing monotypic genus of the family Cyatheaceæ inhabiting the island of Juan Fernandez. Of these some 40 species, so called, were described. They were all based on sterile fronds or parts of fronds, often extremely small and inadequate fragments. Professor Fontaine, after quoting Heer's diagnosis of *Thyrsopteris*[2] writes:

This description, given by Heer for the genus *Thyrsopteris*, so far as the portion pertaining to the sterile frond is concerned, agrees well with a large number of species in the Potomac flora. These I place provisionally in the genus *Thyrsopteris*, on account of the great resemblance that the shape of the pinnules, the lobing, and the nervation show to the sterile forms of various species determined to be *Thyrsopteris* by their fructification. As, however, no fructification is found in the Potomac species, the placing of these plants in the genus must be regarded as provisional. It is quite possible that some of them belong to *Aspidium* and *Dicksonia*.

It should be noted that a number of the species of *Thyrsopteris* described in the following pages show a good many features similar to those of *Sphenopteris mantelli*, as described by Schenk and Heer (p. 120).

Professor Fontaine does identify *Sphenopteris mantelli* from one locality in the Potomac belt, that at Federal Hill, Baltimore, and in discussing its bearing upon the age of the deposits he says:

Now in the Potomac flora not only is *S. mantelli* present in beds which show plants of the most recent facies existing in the formation, but there is a very important group of ferns which, although placed in the genus *Thyrsopteris*, have nearly the nervation and foliage typified in *S. mantelli*. The great development in the Potomac of ferns of the general type of *S. mantelli* gives strong evidence of Wealden or somewhat later age. A somewhat later age than Wealden is indicated, perhaps, as most of the species

[1] Flora foss. Arct., vol. 4, pt. 2, 1877, p. 28.

[2] Seward, Wealden Flora, pt. 1, 1894, p. 40.

are somewhat modified, so as to depart more or less from the typical *S. mantelli*, and to assume the facies of *Thyrsopteris*. The other species of *Sphenopteris* give little help in fixing the age of the Potomac strata (p. 338).

Thus while the most prominent fern element in the Potomac group belongs to a different genus and different family, its resemblance to the *Sphenopteris mantelli* type is so pronounced that it furnishes an argument for the nearly homotaxial age of the containing deposits, surely a curious logic. In his latest work this author identifies a species of *Onychiopsis* from three localities in Virginia and Maryland (Hell Hole, New Reservoir, and Fort Foote).

Again in discussing *Thyrsopteris* at the end of his Potomac flora (1890) he writes:

> It is true that, as no fructification has been found on these ferns, they may be incorrectly placed in the genus *Thyrsopteris*. Still, the very great development in the Potomac flora of ferns with a foliage and nervation so characteristic of the later Jurassic and Lower Cretaceous can not be without significance.
>
> A number of these Thyrsopterids have the same type of foliage as the Wealden ferns, *Sphenopteris mantelli* Brongn.; *S. goepperti* Dunker; *S. cordai* Schenk; *S. plurinervia* Heer; and *S. gomesiana* Heer, as well as the Urgonian plants *Asplenium dicksonianum* Heer; *A. nauck hoffianum* Heer, and various *Dicksonias*, such as *D. johnstrupi* Heer. It is a significant fact that this type of foliage, so common toward the close of the Jurassic and in the oldest Cretaceous, is the most abundant single type in the Potomac strata also. Such a general prevalence of a type is more significant of geological relationship than the identification of a few species common to two formations. It is not worth while to examine in detail the affinities of the different species. Most of them are new and unique. One or two have some resemblance to Oolitic species, while a greater number may be grouped as belonging to the two Wealden types *S. mantelli* and *S. goepperti*.

It will be seen from these lengthy quotations how uncertain the author of these 40 species of *Thyrsopteris* was as to their real botanical affinity, and when the student turns from the text and figures to the actual specimens, the strictures of Professor Seward[1] are found to be abundantly justified. There are 26 species described from a single clay lens at Fredericksburg, Virginia. If the reader will pause to ask himself where in the history of the earth or in the living flora 26 species of a single genus of ferns can be found in a single circumscribed clay lens, or growing in a single circumscribed area, grave doubt as to their validity at once arises; and even if we predicate their having been gathered together by a river system it must needs have been a remarkable river system to have gathered all of these ferns with over 50 other species of ferns and 50 species of gymnosperms, in all 160 different species, and to have deposited them in one quiet pool where clay was forming, a pool not over 15 feet in diameter as preserved and only 4 feet thick, the recognizable remains practically all coming from the basal 3 to 5 inches.

[1] Wealden Flora, pt. 2, 1894, p. 56.

With the large amount of material at his disposal the writer finds it altogether impossible to differentiate the 40 species described by Professor Fontaine from the Potomac group. There are two main types, the narrow pinnule type, that identified in some of the Baltimore specimens as *Sphenopteris mantelli* by Fontaine and including some of the forms described as new species of *Thyrsopteris*, and the broader type exemplified by the foreign *Sphenopteris goepperti*. It is to the latter that a large number of the Potomac forms belong. Three additional species which include the balance of the *Thyrsopteris* forms are characterized. In perusing the synonym of the species which follow, the question is likely to arise in the mind of the reader whether or not the process of ignoring minor differences has not been carried too far, so that it is needful to point out the reasons which have led to the present treatment. The main reason is, of course, that it was found impossible to fix upon any characters of specific value that would hold good for material other than the individual specimen upon which they were based. That the author of these species could not tell them one from the other is quite obvious in looking over the material which passed through his hands, specimens identical in all particulars at one time receiving one name and on a subsequent occasion another, even counterparts of the same specimen being, in at least one instance, identified as distinct species.

These ferns were of large size with tripinnate fronds, so that it is easy to see how one or two species with slight individual variations in form could, when broken up into fragments and fossilized in a matrix for the most part of very arenaceous clay, form the basis for numerous species. The pinnæ from the base of the frond will differ more or less from those higher up and the basal pinnules of the individual pinnæ will differ decidedly from the distal ones. It is possible in the more complete Potomac specimens to trace these variations and so get a number of Fontaine's types on a single specimen so that it seems wiser to consider the bulk of the forms as exemplifying slight variations, due largely to position, rather than to allow them specific or even varietal rank. The published drawings of these forms, especially the enlarged pinnules showing detail, are for the most part inaccurate and idealized to such an extent that even the experts in the National Museum often find it impossible to decide which specimens represent Professor Fontaine's drawings.

With regard to our taking up the genus *Onychiopsis* of the Polypodiaceæ rather than *Thyrsopteris* of the Cyatheaceæ it may be said that while *Thyrsopteris* as a form-genus may not be open to any great degree to criticism, it implies a relationship with the existing species which the evidence does not substantiate so that the best modern usage refers the older type of this sort to the genus *Coniopteris* Brongniart and the later ones to this genus *Onychiopsis*. It is quite possible

that the modern genus *Thyrsopteris* was a prominent Jurassic and older Cretaceous type, there being many parallel cases, as, for example, that of the gymnospermous genus *Ginkgo*. Some of the evidence is at least sufficient to prove that forms so named are referable to the family Cyatheaceæ, so that in considering the Potomac forms we have to decide whether the fact that the Jurassic forms like *Thyrsopteris maakiana* and *Thyrsopteris murrayana* of Heer are members of the Cyatheaceæ, shall be given greater or less weight than the fact that the same type of sterile frond very abundant in the Lower Cretaceous, from England to Japan, should have fertile pinnules like those of the genus *Onychium* of the Polypodiaceæ. It is true that only sterile pinnules are known from the Potomac deposits, but the fertile parts have been found associated and in organic connection with these identical sterile pinnules in nearly homotaxial beds in California, Japan, England, Belgium (?), Bohemia, and Portugal. The writer prefers to believe that the latter evidence is entitled to the greater weight. The modern genus *Onychium* has several widely distributed, chiefly tropical, species of Japan, China, India, Persia, Abyssinia, and the East and West Indies. In this connection attention should be called to the fertile specimens described by Professor Fontaine, from Fredericksburg, as *Aspleniopteris*, since the latter, which is referred to the Asplenieæ, is very similar to the fertile pinnæ of a specimen of *Onychiopsis goepperti* from Japan, kindly communicated by Professor Yokoyama.

ONYCHIOPSIS GOEPPERTI (Schenk) Berry.

Sphenopteris goepperti SCHENK (part), Palaeont., vol. 19, 1871, p. 209 (7), pl. 30 (4) figs. 2, 2*a* (not figs. 3–5 or pl. 35 (9) fig. 2).—SAPORTA, Flora Foss. Portugal, 1894, pp. 71, 123, 159, pl. 18, fig. 6; pl. 33, fig. 8; pl. 29, fig. 6.

Thyrsopteris elongata GEYLER, Palaeont., vol. 24, 1877, p. 221.—SCHENK in Richthofen's China, vol. 4, 1883, p. 263, pl. 54, fig. 1.

Dieksonia elongata YOKOYAMA, Bull. Geol. Soc. Japan, vol. 1, No. 1, 1886, p. 5.

Onychiosis elongata YOKOYAMA, Journ. Coll. Sci. Japan, vol. 3, 1890, p. 27, pl. 2, figs. 1–3; pl. 3, fig. 6*d*; pl. 12, figs. 9, 10.—(?) SEWARD, Wealden Flora, pt. 1, 1894, p. 55, pl. 2, fig. 2.

Thyrsopteris rarinervis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 123, pl. 26, figs. 6, 7; pl. 43, figs. 4–6; pl. 44, figs. 1, 2, 5; pl. 49, fig. 2; pl. 169, figs. 6, 7.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 225, 484, 491, 514, 517, 518, 521, 528, 548, pl. 65, figs. 2–4; pl. 113, figs. 2, 3.

Thyrsopteris alata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 124, pl. 36, fig. 3.

Thyrsopteris meekiana angustiloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 126, pl. 38, figs. 5–7, 9; pl. 43, fig. 8; pl. 44, fig. 3; pl. 47, fig. 4; pl. 48, fig. 1; pl. 54, figs. 2, 11; pl. 55, fig. 1; pl. 56, figs. 1–3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 557.

Thyrsopteris angustiloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 134, pl. 48, figs. 3–5; pl. 55, fig. 3.

Thyrsopteris densifolia FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 129, pl. 39, fig. 3; pl. 40, figs. 2–5; pl. 51, fig. 5.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 484, 511, 517.

Thyrsopteris decurrens FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 130, pl. 43, fig. 7; pl. 46, figs. 2, 4; pl. 49, figs. 5–7.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 484, 491, 511, 525, pl. 111, fig. 11.

Thyrsopteris virginica FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 120, pl. 24, fig. 1.

Thyrsopteris pachyrachis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 132, pl. 46, figs. 3, 5; pl. 47, figs. 1, 2; pl. 49, fig. 1.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 487, 538, 557.

Thyrsopteris elliptica FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p.133, pl. 24, fig. 3; pl. 46, fig. 1; pl. 50, figs. 6, 9; pl. 51, figs. 4, 6, 7; pl. 54, fig. 6; pl. 55, fig. 4; pl. 56, figs. 6, 7; pl. 57, fig. 6; pl. 58, fig. 2.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 3, 1898, p. 482; pt. 2, 1898, p. 482.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 290, 484, 514, 517, 528, 557, pl. 71, figs. 12, 13.—KNOWLTON, Smiths. Misc. Coll., vol. 4, pt. 1, 1907, p. 110.

Thyrsopteris distans FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 134, pl. 47, fig. 3; pl. 54, fig. 8.

Thyrsopteris pinnatifida FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 136, pl. 51, fig. 2; pl. 54, figs. 4, 5, 7; pl. 57, fig. 7.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1890, p. 658, pl. 161, figs. 1, 2.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 511.

Thyrsopteris varians FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 137, pl. 52, figs. 2–4; pl. 53, figs. 1–3; pl. 54, fig. 10; pl. 57, fig. 2.

Thyrsopteris rhombifolia FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 138, pl. 52, fig. 5; pl. 54, fig. 1.

Thyrsopteris bella FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 139, pl. 53, fig. 5; pl. 55, figs. 6, 7; pl. 56, figs. 2, 5; pl. 57, figs. 1, 5; pl. 58, fig. 4.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 491, 511.

Thyrsopteris microloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 140, pl. 57, fig. 4.

Thyrsopteris microloba alata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 140, pl. 55, fig. 5; pl. 58, fig. 1.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 281.

Thyrsopteris inæquipinnata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 142, pl. 57, figs. 3, 8.

Thyrsopteris rhombiloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 144, pl. 89, fig. 7; pl. 60, fig. 8.

Description.—Yokoyama, in 1890, described this species as follows:

Frond slender, bi-tripinnated; sterile pinnæ alternate or rarely opposite, elongated, their length rapidly increasing toward the lower part of the frond; pinnules alternate, acutely directed forward, lanceolate or linearly lanceolate, entire or lobed, or even pinnately parted; lobes or partitions acute at apex and acutely directed forward just like the pinnules themselves. Venation obsolete, secondary veins simple, each going into a lobe. Fertile pinnules elongated, with a linear terminal sorus on both sides of the midrib.

A very large number of Fontaine's species of *Thyrsopteris* fall within the limits of this species. There is, to be sure, some variation in the relative length and breadth of the pinnules, but the material shows every gradation of form, it being possible to select individual pinnules from a single frond fragment which exemplify several of the supposed types. On the whole the pinnules are somewhat more robust

than in the foreign material, and the rachis is inclined to be stouter and may or may not be winged.

This is an exceedingly common form in the Potomac from the oldest to the youngest stratum and it has also been recorded from the Kootenai of Montana at Great Falls, Geyser, etc., and possibly some of Dawson's identifications of *Asplenium dicksonianum* Heer from the Canadian Kootenai should also be referred to this species. It also occurs in the Lakota formation of the Black Hills. Abroad it is rather rare in the English and German Wealden, but its geological distribution in the Lower Cretaceous of Portugal rivals that of eastern America since it comprises considerable material from the Valanginian, Urgonian, and Albian terranes. With regard to its occurrence in the Mesozoic of eastern Asia, Yokoyama writes[1] that it is the "chief and characteristic fossil of the Japanese flora, being found in all of the fossil localities."

That this or *Onychiopsis psilotoides*, or both, occur in the Kome beds of western Greenland seems probable, and several of Heer's species of *Asplenium*, notably *Asplenium dicksonianum* Heer,[2] suggest themselves for comparison. While the writer has not ventured to include any of them in the synonymy of this species, they certainly are very close to this type in appearance. The English occurrence of this species is questioned in the foregoing synonymy since Professor Seward [3] considers the Wealden material as identical with that of *Onychiopsis psilotoides*. This may be true of the Wealden material referred to, but it can hardly apply to that from America and Asia, as the writer will show under the discussion of *Onychiopsis psilotoides*.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Trents Reach, Cockpit Point, Dutch Gap, near Potomac Run, Colchester Road (Pohick Creek?), Virginia; New Reservoir, Ivy City, District of Columbia. ARUNDEL FORMATION: Langdon, District of Columbia, Arlington(?), Maryland. PATAPSCO FORMATION: Federal Hill (Baltimore), Fort Foote, Vinegar Hill, Maryland; near Brooke, White House Bluff, Mount Vernon, Chinkapin Hollow, Virginia.

Collections.—United States National Museum, Goucher College.

ONYCHIOPSIS NERVOSA (Fontaine).

Thyrsopteris nervosa FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 122, pl. 25, figs. 4, 5, 16; pl. 37, figs. 2, 4; pl. 39, fig. 5; pl. 40, fig. 6.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 511, 517, 519, 521, 528, 548, 571.

Thyrsopteris meekiana FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 125, pl. 38, figs. 2–4, 8; pl. 50, figs. 7, 8; pl. 51, fig. 3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 519, 565; pl. 119, fig. 1.

[1] Yokoyama, Journ. Coll. Sci. Japan, vol. 3, 1890, p. 27.

[2] Flora foss. Arct., vol. 3, Abth. 2, 1874, p. 31, pl. 1, figs. 1–5; idem, vol. 6, Abth. 2, 1882, pp. 3, 33, pl. 2, fig. 2; pl. 32, figs. 1–8.

[3] Seward, Ann. S. Afr. Mus., vol. 4, 1903, p. 7.

Thyrsopteris crassinervis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 130, pl. 41, figs. 1–3.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 658, pl. 161, figs. 3, 4.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 513, 528, pl. 112, figs. 5, 6.

Thyrsopteris pecopteroides FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 135, pl. 51, fig. 1.—FONTAINE, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 661, pl. 161, figs. 16–19.

Adiantites parvifolius FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 558, pl. 117, fig. 1.

Thyrsopteris heteroloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 139, pl. 53, fig. 4.

Thyrsopteris obtusiloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 143, pl. 58, figs. 7, 10.

Description.—Frond bipinnate or tripinnate. Principal rachis mediumly stout, somewhat flexuous, sometimes winged in the upper part. Pinnæ alternate or subopposite, ovate to ovate-lanceolate in outline, becoming entire apically, the pinnules passing into dentate teeth while the ultimate pinnæ become dentate pinnules. This character renders distal fragments quite different in appearance from the normal form of this species and quite like *Cladophlebis*. In some individuals the pinnæ lower down on the frond assume this form, constituting the supposed species *Thyrsopteris crassinervis* of Professor Fontaine and well shown in the specimens from Chinkapin Hollow and from near Glymont. Every gradation is shown, however, between this type and the usual type of pinnæ made up of alternate, very oblique, decurrent pinnules, usually rather deeply cut into subrhombic basal lobes, which become ovate or elliptical lobes and finally teeth in passing distad. Base contracted, subpetiolate. Veins numerous and slender but very distinct, branching obliquely, flabellate, repeatedly forked, subparallel. Texture coriaceous.

While the fragments of the fronds of this species are all small, the plant which bore them must have been of considerable dimensions. Representative material is readily distinguished from the other species of *Onychiopsis* recognized, but small fragments are liable to confusion with *Onychiopsis brevifolia;* in fact, Professor Fontaine founded no less than six nominal species upon such fragments, all of which are believed by the writer to represent slight variations of a single species.

It is widely distributed throughout the Potomac group, but not common at any outcrop. Outside this area it has been reported from the Lakota formation of the Black Hills. Practically identical remains from the Lower Cretaceous of Portugal are described by Saporta as various species of *Sphenopteris*.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Potomac Run, Virginia; New Reservoir, Ivy City, District of Columbia; Springfield, Maryland. ARUNDEL FORMATION: Langdon (frequent), District of Columbia. PATAPSCO FORMATION: Chinkapin Hol-

low, Virginia; Fort Foote, near Glymont, Vinegar Hill (?), Federal Hill (Baltimore), Maryland.

Collection.—United States National Museum, Maryland Academy of Science, Goucher College.

ONYCHIOPSIS BREVIFOLIA (Fontaine).

Thrysopteris brevifolia FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 121, pl. 24, figs. 5, 10.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 660, pl. 161, figs. 10–15.

Thrysopteris dentata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 121, pl. 24, figs. 4, 6, 7, 9; pl. 25, figs. 1, 2.

Thrysopteris pachyphylla FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 135, pl. 50, fig. 3.

Thrysopteris nana FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 141, pl. 56, figs. 4, 8.

Thrysopteris heterophylla FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 142, pl. 58, fig. 3.

Thrysopteris sphenopteroides FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 143, pl. 58, fig. 6.

Thrysopteris squarrosa FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 143, pl. 59, fig. 3.

Thrysopteris retusa FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 144, pl. 59, fig. 10.

Description.—Frond small, bipinnate or tripinnate. Rachises rather slender, often winged. Pinnæ alternate to subopposite, relatively long and narrow, divided below, pinnatifid distad. Pinnules much narrowed at the base, decurrent, obliquely toothed or divided, the extent depending upon their position on the frond, triangular ovate to lanceolate in outline. Veins somewhat flabellate, once or twice forked or simple. Texture coriaceous.

This species is not common in the Potomac and is confined to the basal beds in the Virginia area, although it has also been reported from the Lakota formation in the Black Hills region and from the Kootenai formation of Montana. It is represented in the Virginia area by quite a large number of mostly fragmentary specimens showing slight variations in the character of the pinnule lobes or teeth which were made the basis for distinguishing eight species by Prof. Fontaine. It is possible that more than one type is included in the species as defined by the writer, the nature of the material rendering certainty out of the question; but if the test of the validity of a species be the possibility of its being recognized a second time by either the original author or other students it must be admitted that these eight so-called species are not good species.

Onchiopsis brevifolia differs from *Onychiopsis goepperti* and *psilotoides* principally in the smaller fronds, less robust pinnules, which are also less ascending, and in the much less elongate character of the pinnæ and especially the pinnules. It is a much smaller and less robust form than *Onychiopsis latiloba*, from which it is readily distinguished, but approaches somewhat close to *Onychiopsis nervosa*.

The latter species is on the whole a larger form with less elongate and more triangular pinnæ, and the pinnules have more entire margins, the lobes or teeth being rounded and not angular. The veins are also more numerous.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Potomac Run, Telegraph Station (Lorton), Virginia.

Collections.—United States National Museum.

ONYCHIOPSIS PSILOTOIDES (Stokes and Webb) Ward.

Hymenopteris psilotoides STOKES and WEBB, Trans. Geol. Soc. London, ser. 2, vol. 1, 1824, p. 424, pl. 46, fig. 7; pl. 47, fig. 2.

Sphenopteris mantelli BRONGNIART, in Mantell, Illus. of the Geol. of Sussex (rev. ed.), 1827, p. 55, pl. 1, figs. 3*a*, *b;* pl. 3, figs. 6, 7; pl. 3*A*, fig. 2.—SCHENK, Palaeont., vol. 19, 1871, p. 208, pl. 23, fig. 1–8; pl. 4, fig. 6 (?); vol. 23, 1875, p. 158, pl. 28, fig. 12.—HEER, Contr. Flora Foss. Portugal, 1881, p. 12, pl. 11, figs. 1–5; pl. 12, figs. 2*b*, 2*bb*.—FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 91, pl. 1, figs. 1, 2.—SAPORTA, Flora foss. Portugal, 1894, pp. 72, 124, 157, pl. 15, figs. 8–12; pl. 18, fig. 5; pl. 23, figs. 1, 2, 8; pl. 28, fig. 2; pl. 29, fig. 1; pl. 30, figs. 9, 10; pl. 31, figs. 1, 2.

Onychiopsis mantelli SEWARD, Wealden Flora, pt. 1, 1894, p. 41, figs. 4, 5 on p. 50; fig. 6 on p. 52, pl. 2, fig. 1; pl. 13, figs. 1–4; Flora Weald. de Bernissart, 1900, p. 15, pl. 1, figs. 17–19; pl. 2, figs. 20, 21; Ann. S. Afr. Mus., vol. 4, 1903, p. 5, pl. 1; pl. 5, fig. 1.

Thyrsopteris insignis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 127, pl. 39, fig. 4; pl. 40, fig. 1; pl. 41, fig. 6; pl. 43, figs. 1, 2, 4; pl. 53, figs. 1, 3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 521.

Thyrsopteris insignis angustipennis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 128, pl. 43, fig. 2.

Thyrsopteris angustifolia FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 131, pl. 44, fig. 4; pl. 45, fig. 3; pl. 48, fig. 2; pl. 49. figs. 3, 4; pl. 55, fig. 2; pl. 58, fig. 8.—FONTAINE, in Ward, Monogr. U. S. Geol. Sur., vol. 48, 1906, p. 516.

Thyrsopteris microphylla FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 151, pl. 45, figs. 1, 2, 4, 5.

Thyrsopteris rarinervis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 123, pl. 26, figs. 6, 7; pl. 43, figs. 4–6; pl. 44, figs. 1, 2, 5; pl. 49, fig. 2; pl. 169, figs. 6, 7.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 225, 484, 491, 514, 517, 518, 519, 521, 528, 548, 558, pl. 65, figs. 2–4; pl. 113, figs. 2, 3.

Thyrsopteris dentifolia FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 660, pl. 161, figs. 6–9.

Onychiopsis psilotoides WARD, in Fontaine, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 155 (name only).—FONTAINE, in Ward, Monogr., U. S. Geol. Surv., vol. 48, 1906, pp. 506, 518, 528, pl. 111, fig. 4; pl. 113, fig. 1.—KNOWLTON, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 380.

Description.—The following description was given by Seward in 1894:

Frond tripinnate, ovate lanceolate, rachis winged and prominent; pinnæ lanceolate, alternate, approximate, given off from the main rachis at an acute angle. Pinnules alternate, narrow, lanceolate acuminate, uninerved, of nervation type Coeopterides (Luerssen, in Rabenhorst's Krypt. Fl., vol. 3, p. 11); the larger ones serrate and gradually passing into pinnæ with narrow ultimate segments. Fructification in the form of sessile or shortly stalked linear ovate segments with rugose surfaces, and terminating usually in a very short awn-like apical prolongation.

This species is not nearly so common in the Potomac as is *Onychiopsis gœpperti*, although it appears to have a wider range and be more common abroad. It occurs at all horizons in the Potomac, however, a vertical range which is paralleled by its range from the Valanginian through the Urgonian into the Albian of Portugal. Elsewhere in Europe it has been found in the Wealden of England, Belgium, and Germany, the Neocomian near Quedlinburg, Saxony, and in the Urgonian of Austria. Forms which are identical, according to Seward,[1] are found in the Uintenhage series of South Africa. In this country outside of the Potomac it is found in the Kootenai at Great Falls, Montana, in the Shasta beds of California, and in the Lakota formation of the Black Hills.

The forms identified as this species from the supposed Jurassic near Cape Lisburne, Alaska, have been shown by Knowlton to be forms of *Dicksonia*. Saporta in his treatment of the Portuguese forms leaves them in the genus *Sphenopteris* but thinks that they are more closely related to certain modern species of *Davallia* than to *Onychium*. His figures, however, do not bring this out with any degree of certainty. Professor Seward, in discussing specimens from South Africa,[1] unites with this species the Japanese Jurassic and Cretaceous forms designated as *Thyrsopteris elongata* Geyler and *Onychiopsis elongata* Yokoyama. The reason for the proposed change is the discovery in the English Wealden of more extensive material which showed the *psilotoides* type of pinnule apically and the *elongata* type of pinnule proximally. It is quite possible that the remains from the English Wealden are all one species, but it certainly does not follow that the synonymy follows such a disposition. The American remains identified with the *elongata* type show that the forms with broader segments are not basal portions of fronds with the distal characters of *psilotoides*, although there is in most ferns more or less diminution in size upward. Through the kindness of Professor Yokoyama the writer has received specimens of *O. elongata* from the Jurassic of Kaga, Japan, and these are certainly specifically distinct, especially in the fertile pinnæ, from the English forms of *psilotoides*. They are, therefore, included in the present discussion under *O. goepperti*, which is retained as a distinct species.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Trents Reach, near Potomac Run, Virginia; New Reservoir, Sixteenth Street, District of Columbia. ARUNDEL FORMATION: Langdon, District of Columbia. Bay View, Maryland. PATAPSCO FORMATION: Federal Hill (Baltimore), Stump Neck, near Wellhams, Maryland: Near Brooke, Hell Hole, Virginia.

Collections.—United States National Museum.

[1] Seward, Ann. S. Afr. Mus., vol. 4, 1903, p. 5.

ONYCHIOPSIS LATILOBA (Fontaine).

Sphenopteris latiloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 90, pl. 35, figs. 3–5; pl. 36, figs. 4–9; pl. 37, fig. 1.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 281, 479, 491, 511, 534, 557.

Thyrsopteris brevipennis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 124, pl. 34, fig. 3; pl. 36, fig. 2; pl. 37, figs. 3, 9; pl. 38, fig. 1; pl. 41, fig. 4.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 662, pl. 162, fig. 1*a*.

Thyrsopteris divaricata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 125; pl. 37, figs. 5–8; pl. 70, fig. 1.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 504, 511, 517, 521.

Thyrsopteris crenata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 127, pl. 39, figs. 1, 2.

Description.—Frond large tripinnate; principal rachis very stout sometimes winged. Leaf-substance thin but coriaceous. Primary pinnæ opposite or subopposite with a stout, rigid, rachis, which is often somewhat flexuous; ultimate pinnæ remotely placed, very short, decurrent, passing toward the summit of the principal pinnæ or of the frond through lobed pinnules into entire ones. Pinnules somewhat remotely placed, cuneate at base, those in the lower part of the frond cut more or less deeply into oblong acute to obtuse lobes, passing toward the tips of the ultimate pinnæ into lobed pinnules like those of the upper part of the frond, and at the tips into ovate or oblong lobes and teeth. In the upper part of the frond they are elliptical, three lobed, or entire. All the pinnules and segments are broad. The ultimate pinnæ and the pinnules of the lower part of the frond usually terminate in three lobed segments or in broad elliptical pinnules. The veins are copiously branched, diverging flabellately into the lobes and teeth, and are very distinct and strong, although not coarse.

This is a fine, large species, probably arborescent, and quite distinct from the other species of *Onychiopsis*. It is common throughout the Potomac but rather less abundant in the Patapsco formation than in the older beds. It has been recorded from the Lakota formation in the Black Hills area and from the Kootenai formation in both Montana and British Columbia. There is some variation exhibited by the various forms referred by the writer to this species, and some of the smaller ultimate pinnæ are readily confused with other species of *Onychiopsis*.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Telegraph Station (Lorton), Virginia; New Reservoir (?), District of Columbia. ARUNDEL FORMATION: Langdon (?), District of Columbia; Bewley estate (?), Bay View (common), Maryland. PATAPSCO FORMATION: Deep Bottom, Mount Vernon, Hell Hole (?), Chinkapin Hollow (?), Virginia; Federal Hill (Baltimore), Maryland.

Collections.—United States National Museum, Johns Hopkins University, Goucher College.